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Predicting Academic Performance in Mathematics through Online Learning Constructs and Content Proficiencies

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Abstract. This study explores the evaluation of online distance learning as a significant alternative to traditional education, specifically focusing on its application in Grade 11 mathematics education. The research, conducted in six public senior high schools in Quezon City District IV, employs a descriptive-correlational design and involves 873 Grade 11 students attending online classes. Constructs of online learning, including motivation, access and use of technology, perception, self-directed learning, and online teaching approaches, were examined to understand their impact on mathematics academic performance. The findings revealed that students strongly embraced self-directed learning in the online environment, demonstrating high motivation. Positive feedback was observed towards technology use, online teaching approaches, and the overall perception of online learning. Academic performance was generally satisfactory, with diverse achievements in content-based competencies like Functions and Their Graphs, Mathematics of Investment, and Math Logic. Significant low positive relationships were identified between mathematics academic performance and online learning constructs, as well as content-based competencies. Key predictors of mathematics academic performance included motivation, technology access and use, and online teaching approaches. However, the perception of online learning and self-directed learning did not significantly predict academic performance. These findings contribute to a multiple linear regression model explaining 24% of the variance, highlighting the need to optimize online learning for enhanced mathematics academic performance. Recommendations include students enhancing technology skills and self-directed learning, considering specialized mathematics classes, teachers intensifying instruction in crucial areas, and the Department of Education sustaining the Open High School program while simplifying essential learning competencies in General Mathematics. Future research should explore additional online learning factors for a comprehensive understanding of the subject.

Keywords: Online learning constructs; Content proficiencies in Mathematics; General Mathematics; Academic performance; Descriptive-correlational.

1.0 Introduction

The immense impact of COVID-19 compels the education sector with the need to shift from the traditional classroom to distance education for continuity of learning. The global outbreak of COVID-19 has not only impacted the economic and health sectors but has also significantly affected the education sector. The shift to online learning has also stressed the importance of teacher training and support for effective online instruction (Van Wart et al., 2021). Additionally, concerns have been raised about digital equity and the need for innovative solutions to ensure all students have equal access to quality education. Even though it is a mainstream education, various reported challenges and problems encountered by teachers and students are inevitable. In Southeast Asia, Basar et. al. (2021) discussed in their paper that the implementation of online learning must examine its effectiveness and the challenges that learners experience in terms of participation, accessibility,

stable internet connection, and motivation to learn. It is of paramount importance to consider various factors in the online learning environment to determine its effectiveness and empirically understand its influence on student learning and achievement. The term "constructs" is used by the researcher to denote factors, dimensions, or domains of the online learning modality, as this has been proven by several related empirical studies to be a multidimensional variable (Rahayu et. al., 2021; Kamaruzaman et al., 2022). Moreover, Pham et al. (2021) explored and assessed six significant factors that affect online learning outcomes: learner characteristics, perceived usefulness, course content, course design, ease of use, and faculty capacity. This study adopted the framework of Kamaruzaman et al. (2022) which consists of dimensions of online modality such as motivation, access and use of technology, perception of online learning, self-directed learning, and online teaching approach.

In the local context, the Department of Education Philippines implemented the Basic Education Learning Continuity Plan enforcing the adoption of alternative delivery modes of teaching and learning (DepEd, 2020). Online distance learning becomes one of the alternative modalities that consists of latent constructs or dimensions to evaluate its effectiveness based on students' perspectives. In the current situation in Philippine public schools, online and modular learning emerges as a crucial alternative during unforeseen disruptions to face-to-face classes, such as weather disturbances, extreme temperatures, and transport strikes. Hermosisima et al. (2023) and Nord Anglia Education (2021) stressed that online teaching provides accessibility, flexibility, and continuity of learning. Access and use of technology is an indispensable factor of e-learning which needs to be assessed based on the learner's skill in using online platforms and gadgets as well as a strong internet connection (Al Rawashdeh et al., 2021). Self-directed learning is considered an important skill to attain better academic performance because this remote set-up requires students, especially the senior high school and college level, to be independent and responsible for their learning. Hua et al. (2024) recently found that self-directed learning skills had positive effects on the online learning satisfaction of students. The Teaching Approach in Online set-up and the Motivation of learners to attend online classes and participate in distance learning tasks play an important role in achieving effective learning (Mazhar et al., 2020; Ozer & Badem, 2022). The students' Perception of Online Learning reflects their remote learning experience and how they interact and adjust to this new learning setup (Purwadi et al., 2021).

Mathematics holds a crucial position in the education of senior high school students, particularly as they prepare for their chosen fields within the existing Basic Education Curriculum. The academic performance in mathematics serves as a gauge of how effectively students achieve content-based competencies and skills. Challenges in attaining improved mathematics achievement have been persistent concerns for both teachers and students, both before and during the pandemic. Numerous related studies have assessed the implementation of the Senior High School (SHS) curriculum, focusing on General Mathematics, and examining the scenario before, during, and after the pandemic (Del Rosario & Medina, 2022; Pagaran et al. 2022; Mamolo & Sugano, 2020; Jaudinez, 2019). These highlighted the importance of considering the Most Essential Competencies as integral features of the Basic Education Learning Continuity Plan 2020. It is critical for assessing effectiveness and monitoring the content knowledge, skills, and academic progress of senior high school students. In the school year 2019-2020, Herrera (2019) conducted a descriptive study in four DepEd-managed senior high schools in Luna, Apayao, Region 1. The findings revealed that out of 156 Filipino senior high school students, 37.82% achieved grades between 75 to 79, and 41 students achieved grades ranging from 80 to 84. Further investigation into the mathematics academic performance of senior high school students was carried out by Capinding (2021) during the school year 2020-2021 at Nueva Ecija University of Science and Technology. The study unveiled that out of 211 students, 27.49% received final grades ranging from 75 to 79, while 28.91% attained final grades falling within the satisfactory level.

In Congressional District IV of Quezon City, the locale of this study where the majority of students choose online as their modality, school overall data of final grades from teachers indicated that student's Mathematics performance has oscillating trends in three public schools such as Final Grades of 85 to 89 during SY 2019-2020, Final Grades of 75 to 85 in SY 2020-2021, and Final Grades of 80 to 84 in SY 2021-2022. At Jose V. Palma Senior High School in Quezon City, the public high school where the researcher is currently employed, the average General mathematics grades in SY 2019-2020, SY 2020-2021, and SY 2021-2022 are 84.25, 79.74, and 80.83, respectively. The observed disparities in schools on the fluctuating trend on average Mathematics academic performance may be attributed to the influence of the factors, constructs, or dimensions of online distance

learning such as Motivation, Access, and Use of Technology, Self-Directed Learning, Perception of Online Learning, and Online Teaching Approach. Engaging in synchronous remote classes could potentially impact students' success positively or negatively, depending on these factors.

In light of the provided information, concerns, difficulties, and the absence of a statistical model explaining mathematics academic performance in a remote setup, a quantitative study is necessary to explore the predictive associations between the elements of online learning methods, proficiency in mathematical content knowledge and skills, and academic achievements in mathematics.

2.0 Methodology

2.1 Research Design

This present study utilized descriptive correlational design as it aimed to further investigate the predictive relationship between the online learning constructs, assessment of most essential learning competencies, and General Mathematics academic performance. The researcher included the online learning dimensions as a potential group of variables that affect the academic performance of the respondents in General Mathematics in the online learning context. According to Chiang et al. (2020), the research design is appropriate as it involves the measurement of several independent variables that may be influencing a single dependent variable. Furthermore, this study utilized an observational research design. It gathered and observed online learning variables and the mathematics proficiencies of the respondents in their natural settings, without manipulation. Observational design is appropriate for observing, collecting, and measuring variables in their natural settings without manipulation (Creswell, 2009).

2.2 Research Participants

The respondents of this study were 873 out of 1531 Grade 11 students under the online modality of SY 2021-2022 from six randomly selected public SHS in Congressional District IV of Quezon City. The selected schools with a corresponding number of respondents are Krus Na Ligas High School (109), Carlos L. Albert High School (110), Quezon City High School (122), Ramon Magsaysay Cubao High School (315), Eugenio Lopez Jr. Center for Media Arts SHS (149), and Flora A. Ylagan HS (68).

Cluster Random Sampling was employed for respondent selection, as it is a suitable technique for quantitative studies seeking to perform statistical inference (Mananghaya, 2020). The researcher randomly chose six (6) public senior high schools out of the twelve (12) in District IV. The sample included all learners in the online modality. Employing Statistical Power Analysis with GPower Software with a specified statistical test in A Priori Type, a minimum sample size of 146 was calculated at a 0.15 effect size and 95% confidence level. The actual sample size exceeded the minimum required.

2.3 Research Instrument

The researcher developed the Online Learning Assessment Scale (OLAS) to gather the necessary data on respondent's agreement on mathematics online learning. The following dimensions were adapted and used in the initial steps of item development: Motivation (8 items), Access and Use of Technology (7 items), Opinion on Online Learning (6 items), Self-Directed Learning (8 items), and Online Teaching Approach (8 items). The indicators of this instrument were based on the study of Sharma et. al. (2020) and Kamaruzaman et al. (2022). The other questionnaire is the researcher-made test which is the Most Essential Learning Competencies Assessment Tool (MAT) in the form of a 30-item multiple choice test. Domains of this instrument are Functions and their Graphs (14 items), Math of Investment (6 items), and Math Logic (10 items). The online learning assessment scale is a Likert scale instrument with four options to determine the level of agreement of the respondents in each indicator: 4 – Strongly Agree, 3 – Agree, 2 – Disagree, and 1 – Strongly Disagree.

The Online Learning Assessment Scale (OLAS) was assessed in terms of face validity and content validity by seven (7) experts (master teachers, principals, and subject area coordinators from Quezon City and Valenzuela City) in Mathematics, Statistics, and language. The instrument was evaluated with an overall Scale Content Validity Index of 0.85 which was verbally interpreted as an accepted value (Yusoff, 2019). The questionnaire was pilot-tested for testing the reliability and conducting the item analysis at Manuel A. Roxas High School (17 participants) and Jose V. Palma SHS (18 participants). As a result, the scale was considered to be internally

consistent based on Cronbach's Alpha Coefficient of 0.745 for motivation, 0.70 for access and use of technology, 0.70 for perception of online learning, 0.745 for self-directed learning, and 0.846 for online teaching approach. Each reliability index was interpreted to be internally consistent since each computed value is at least 0.70 (Adamson & Prion, 2013). The Content validity was checked by the validators for the alignment of the test items in the learning competencies in the MELC Assessment tool for General Mathematics. Table of Specifications (TOS) was drafted and used by the researcher for this instrument to relate the instructional objectives to the course content (SAGE Research Methods, 2018). Item Analysis was conducted by the researcher and the results showed that the difficulty index ranged from 0.44 to 0.63 which means the items are moderately difficult while the discriminant index ranged from 0.31 to 0.44 which is interpreted as very good items (Calmorin, 2004).

2.4 Data Gathering Procedure

The researcher employed Google Forms to streamline the collection of responses from the designated participants. Both online and in-person orientations were carried out to elucidate the research objectives and anticipated outcomes, ensuring the precision and comprehensiveness of the responses. Before the pilot testing and actual administration of the online validated instrument, a written communication for approval was sent to the Department of Education - Schools Division Office of Quezon City to conform to the necessary protocol and procedures. After the approval, two letters (approval and consent form) addressed to the school heads, math teachers, and parents were sent to the randomly selected schools to virtually administer the survey. The responses were checked consistently and gradually to determine the degree of completion of submitted answers. Follow-up on the responses was done through virtual communication, email, phone calls, and personal visits to the SHS Math teachers, the Head Teacher of the Mathematics Department, and SHS focal persons. After the data screening and inspection of responses in Google Forms, the researcher tabulated and processed the Likert Scale data using MS Excel and SPSS (Statistical Package for Social Sciences). Data screening was done to avoid missing values. The data set was organized and analyzed.

2.5 Data Analysis

Weighted mean was used by the researcher to determine the Grade 11 students' responses regarding their level of agreement in Mathematics online learning. This was used to describe the online learning dimensions of the respondents. The average of responses in each indicator per online learning dimensions was computed using this type of mean. The arithmetic mean was used to compute the average academic performance (final grades) in General Mathematics and average scores in the assessment of content proficiencies in General Mathematics of the respondents. Standard deviation was employed to find out the degree of variances of the scores in the assessment of content proficiencies in General Mathematics.

Frequency counts and percentage distributions were employed to summarize the mathematics academic performance of the respondents. The descriptive rating based on the School Form 9 (Report Card) was used. The researcher used Spearman's Rho correlation to assess the relationship between online learning dimensions and mathematics academic performance, as well as the assessment of content-based competencies and mathematics academic performance. This statistical procedure was deemed appropriate because the data set did not meet the assumptions of parametric tests. Spearman's Rho is preferred over Pearson correlation when dealing with Likert Scale variables measured on an ordinal scale (Abordo, 2023).

Multiple Linear Regression, a statistical modeling procedure, was utilized since this is aligned with the research design. If there are a series of values for two or more correlated variables under study, then it is possible to predict or estimate the value of one variable from the knowledge of other variables (Espinola, 2021).

2.6 Ethical Considerations

Charlesworth Author Services (2017) discussed specific key principles of ethical standards in conducting research. These key principles enable the present study to be well-guided in terms of regulations and restrictions. The principle of recruiting participants was followed as the researcher observed the privacy of the information from the respondents and was not pressured to participate. The researcher adhered to the principle of obtaining informed consent by providing a parent's consent form to each respondent during both the pilot testing and the actual administration of the survey.

To highly protect the data and information in the Google Form Survey, the researcher required only all Grade 11 students with DepEd Quezon City Gmail Accounts to answer the electronic survey form. After obtaining all the necessary information last May 30, 2022, the researcher closed the Google Form for responses by changing the privacy settings. Only the Excel File of the organized data set remained as the original copy of all responses because after performing the data analysis and producing results and findings, the researcher deleted the Excel File and the survey to ensure that other persons would not be able to access the information. Respondents' information and actual answers in the survey were not archived in any public data storage. Scored assessment data, materials, and score sheets were deleted after one year of conducting the study.

3.0 Results and Discussion

3.1 Description of the Online Learning Constructs

Description of the Online Learning Constructs in Terms of Motivation

Table 1. Description of the online learning constructs in terms of motivation

INDICATORS	WEIGHTED MEAN	VERBAL INTERPRETATION
1. I am optimistic about the use of technology in learning mathematics online.	3.52	Strongly Agree
2. I embrace learning new things regarding online learning in mathematics.	3.42	Strongly Agree
3. I am updated with the latest technology in learning mathematics.	3.39	Strongly Agree
4. I used my significant time, effort, and energy to learn mathematics in online classes	3.38	Strongly Agree
5. I am certain that I understand the math concepts being taught in synchronous classes.	3.37	Strongly Agree
6. I have a wide interest in ICT about learning mathematics online.	3.36	Strongly Agree
7. I like what I am learning in mathematics online.	3.36	Strongly Agree
8. I am not confident in using online distance learning as my modality to learn mathematics.	2.79	Agree
Overall Weighted Mean	**3.32**	**Strongly Agree**

Presented in Table 1 were the weighted mean and corresponding interpretation of the description of the online learning constructs in terms of motivation. As gleaned from the table, the top 3 indicators of Motivation in rank are "I am optimistic about the use of technology in learning mathematics via online" with a weighted mean of 3.52 or Strongly Agree, "I embrace to learn new things regarding online learning in mathematics" with a weighted mean of 3.42 or Strongly Agree, and "I am updated with the latest technology in learning mathematics" with a weighted mean of 3.36 or Strongly Agree. The Grade 11 respondents strongly agreed that they are motivated to engage in learning mathematics using online modality. This implies that respondents have achieved a certain level of motivation in studying mathematics online despite the pandemic.

The results on Motivation were contradicted in the study of Fulgencio et al. (2021) as well as the investigation made by Mamolo (2022) which showed those students in mathematics were less motivated in their studies online. On the other hand, Cabansag et al. (2021) had the same findings that students were broadly motivated to attend and participate in their online classes.

Description of the Online Learning Constructs in Terms of Access and Use of Technology

Shown in Table 2 were the weighted mean and the corresponding verbal interpretation of the description of online learning constructs in terms of access and use of technology. Based on the results, the respondents agreed that they were knowledgeable in the basic functions of the gadgets used in online modality based on the highest weighted mean of 3.50 which is described as "Strongly Agree." Other indicators show that respondents used video lessons and tutorials to learn Mathematics and they have devices to use in their synchronous and asynchronous classes in Mathematics as numerically shown in the weighted mean of 3.37 and 3.34 which are both described as "Strongly Agree." On the other hand, indicators about not being aware of netiquette and not being aware of the web browsers when doing research were both disagreed by the respondents. The respondents agreed that accessibility of technology, internet connection, online learning resources as well as being well-equipped to use gadgets and asynchronous tools are indispensable in learning mathematics online.

Table 2. Description of the online learning constructs in terms of access and use of technology

INDICATORS	WEIGHTED MEAN	VERBAL INTERPRETATION
1. I know the basic functions of my gadget (cellphone, tablet, laptop, or desktop computer).	3.50	Strongly Agree
2. I used video lessons and tutorials as a reference in my mathematics lessons.	3.37	Strongly Agree
3. I have a device (cellphone, tablet, or computer) to access synchronous classes in mathematics.	3.34	Strongly Agree
4. I know how to access online educational resource sites and libraries.	3.22	Agree
5. I know how to utilize asynchronous tools for my mathematics subject.	3.19	Agree
6. I am not aware of the netiquette when engaging in learning mathematics online.	2.46	Disagree
7. I do not know how to use web browsers when doing research activities.	2.42	Disagree
Overall Weighted Mean	**3.07**	**Agree**

The findings discussed above aligned with those of Eze et al. (2020), who investigated the relationship between technology-related factors such as accessibility, ease of use, and internet service, and students' adoption of ICT learning facilities.

Description of the Online Learning Constructs in Terms of Perception of Online Learning

Table 3. Description of the online learning constructs in terms of perception of online learning

INDICATORS	WEIGHTED MEAN	VERBAL INTERPRETATION
1. I find myself saving money since the start of online classes because I do not spend transportation costs.	3.40	Strongly Agree
2. Online learning improves and simplifies the learning in mathematics.	3.33	Strongly Agree
3. Online learning provides flexibility in terms of studying time in mathematics subjects convenient to the learner.	3.30	Strongly Agree
4. Online learning can make studying mathematics accessible to people regardless of their location.	3.22	Agree
5. The setup of the online learning modality is not compatible with the way I learn mathematics.	3.20	Agree
6. Online modality is not effective an alternative form of learning.	2.63	Agree
Overall Weighted Mean	**3.18**	**Agree**

Table 3 displays the weighted mean and the corresponding verbal interpretations of the description of the online learning constructs in terms of perception of online learning. As observed from the matrix, an overall extent of agreement of 3.18 which is verbally described as "Agree," implies that respondents in general had positive perceptions of using online modality in learning Mathematics. Respondents highly rated the indicator "I find myself saving money since the start of online class because I do not spend transportation costs" as indicated in the weighted mean of 3.40 which is verbally described as "Strongly Agree." The second in rank indicator is "Online Learning improves and simplifies the learning in Mathematics," with a weighted mean of 3.33 which is verbally interpreted as "Strongly Agree." The third in rank among the indicators is "Online learning provides flexibility in terms of studying time in Mathematics subject convenient to the learner," with a weighted mean of 3.30 which is described as "Strongly Agree." The perceptions of online learning of the student-respondents were positive as they agreed that online modality effectively helps students to learn Mathematics in terms of time, flexibility, accessibility regardless of location, and budget saving in transportation costs.

These findings are consistent with the research conducted by Baczek et al. (2021), which highlighted the perceived advantages of online learning, including the ability to study from home, continuous access to online materials, the opportunity to learn at one's own pace, and the comfort of one's surroundings. On the contrary, the findings were contradicted by the study of Harefa and Sihombing (2022) which revealed negative perceptions of online learning being less effective in remote areas due to network and communication issues.

Description of the Online Learning Constructs in Terms of Self-Directed Learning

Table 4. Description of the online learning constructs in terms of self-directed learning

INDICATORS	WEIGHTED MEAN	VERBAL INTERPRETATION
1. I carry out my study guide and plan in mathematics subject.	3.43	Strongly Agree
2. I repeatedly use uploaded mathematics modules in Google Classroom based on my needs.	3.40	Strongly Agree
3. In this online learning modality, I expect high learning performance in mathematics.	3.37	Strongly Agree
4. I study my math lessons in advance using supplementary video tutorials on YouTube and e-books.	3.37	Strongly Agree
5. I can complete my assignments in mathematics online even if there are distractions.	3.36	Strongly Agree
6. I ask for assistance when dealing with difficult mathematics learning tasks via online.	3.35	Strongly Agree
7. I can discipline myself and organize my time to avoid the bulk of work.	3.35	Strongly Agree
8. I feel online learning makes me aware of my study plan in mathematics subject.	3.27	Strongly Agree
Overall Weighted Mean	**3.36**	**Strongly Agree**

Shown in Table 4 were the weighted mean and corresponding verbal interpretation of the online learning constructs in terms of self-directed learning. Based on the results, among the five online learning dimensions, Self-Directed Learning has the highest weighted mean of 3.36 which is verbally described as "Strongly Agree." The students "strongly agree" that they create their study guide and plan for the Mathematics subject (weighted mean = 3.43) and that they frequently use uploaded Mathematics modules in Google Classroom based on their needs (weighted mean = 3.40). These two indicators rank first and second, respectively. Lastly, third in rank are the indicators "In this online learning modality, I expect high learning performance in Mathematics" and "I study my math lessons in advance using supplementary video tutorials on YouTube and e-books," with a weighted mean of 3.37 which is verbally interpreted as "Strongly Agree." The student-respondents strongly agreed that they possess self-directed learning characteristics which are vital to succeed in remote learning set-up. This level of agreement on self-directed learning implies that respondents were independent learners.

The results on Self-Directed Learning were also confirmed by the study by Van Der Vleuten et al. (2020) that the perception of students in self-directed learning has increased during the academic year 2020. Moreover, the findings stated in the previous text were supported by Sun et al. (2022) which indicated that having a self-directed learning attitude has a positive effect on learning engagement provided that the learners have the perceived value of knowing the learning goals.

Description of the Online Learning Constructs in Terms of Online Teaching Approach

Table 5. Description of the online learning constructs in terms of online teaching approach

INDICATORS	WEIGHTED MEAN	VERBAL INTERPRETATION
1. My mathematics teacher gives online assessments that are relevant to the objectives of our lessons.	3.67	Strongly Agree
2. My mathematics teacher provides feedback during and after doing the asynchronous tasks.	3.40	Strongly Agree
3. My mathematics teacher stimulated my interest in learning mathematics online.	3.29	Strongly Agree
4. The teaching approach of my mathematics teacher online is enjoyable.	3.21	Agree
5. My mathematics teacher uses instructional videos as supplementary materials which are integrated into our online discussion.	3.18	Agree
6. My mathematics teacher is well-versed in using techniques in teaching online classes.	3.15	Agree
7. My mathematics teacher gives clear and specific directions during synchronous and asynchronous classes.	3.10	Agree
8. My mathematics teacher does not use online games or interactive activities that make learning enjoyable.	2.78	Agree
Overall Weighted Mean	**3.22**	**Agree**

Presented in Table 5 were the weighted mean and corresponding verbal interpretation of the online learning constructs in terms of self-directed learning. As observed from the matrix, the respondents strongly agreed that their Mathematics teachers provide relevant online assessments based on the learning objectives. The respondents rated the indicator "My Mathematics teacher gives online assessments that are relevant to the objectives of our lessons,' as "Strongly Agree" based on a weighted mean of 3.67. Providing feedbacks from their Mathematics teachers were observed by the respondents based on the weighted mean of 3.40 which verbally describes "Strongly Agree." Respondents also strongly agreed that their mathematics teachers stimulated their interest in learning Mathematics via online as they had a 3.29 level of agreement. The online teaching approach was positively perceived by the student-respondents as they strongly agreed that their Mathematics teachers effectively deliver synchronous and asynchronous lessons, provide feedback, give relevant online assessments, and stimulate their interest in learning Mathematics in an online set-up.

These findings were confirmed also in the study of Van Wart et al. (2021) which found that Teaching Presence and Instructional Support are among the top seven explored factors of online learning success based on students' perspectives. In addition to this, the related study of Gopal et al. (2021) is aligned with the results as they included the quality of online instruction and prompt feedback of teachers as independent factors that positively affect student satisfaction.

3.2 Performance of the Respondents Based on the Assessment of Content Proficiencies in General Mathematics

Table 6. Performance of the respondents in general mathematics

AREAS OF MOST ESSENTIAL LEARNING COMPETENCIES	NUMBER OF ITEMS	MEAN	SD	INTERPRETATION
Functions and Their Graphs	14	13.00	2.33	Outstanding
Mathematics of Investment	6	2.00	0.66	Did not meet expectations
Math Logic	10	6.00	2.03	Satisfactory
Total Items/Overall Mean Score	**30**	**21.00**		**Very Satisfactory**

Table 6 shows the mean and standard deviation of the performance of the respondents based on the assessment of content proficiencies in three areas of General Mathematics. As noticed from the matrix, the data revealed that the overall average score in the 30-item assessment of the most essential learning competencies (MELCs) in General Mathematics is 21.00 being rated as very satisfactory. With the highest average score of 13 out of 14 points in Functions and their Graphs, these results suggest that most students have achieved a desirable level of mastery. However, students are still developing their skills in the areas of Mathematics of Investment and Math Logic, with average scores of 2 out of 6 points and 6 out of 10 points, respectively. These scores indicate that the respondents did not meet the expected competencies in Mathematics of Investment and had a satisfactory level of performance in Math Logic. The test results show that there is an ongoing need to enhance the most essential competencies of learners in the two areas of General Mathematics which are typically covered during the second quarter of the first semester.

Mamolo and Sugano (2020) had related findings as their investigation resulted in fair assessment levels in each area of General Mathematics based on actual scores of the Grade 11 students. This can be also aligned with the detailed analysis made by Refugio et al. (2021) and Jaudinez et al. (2019) which found various challenges in the teaching and learning of the said core subject such as the length of time to cover all the lessons and the bulk of topics in General Mathematics. The overall average score of 21 out of 30 items can be paralleled in the study of Mamolo and Sugano (2020) which revealed that the actual learning competency in General Mathematics was fair based on most scores obtained fall under 17 to 32 out of 80 summative items test.

3.3 Academic Performance of the Respondents in General Mathematics

Table 7 shows the ranking of the academic performance of the respondents in General Mathematics. As gleaned from the table, it was observed that among the 873 Grade 11 respondents, 302 (35%) had final grades ranging from 80 to 84 which is rated as "Satisfactory." Aside from this, 252 (29%) out of 873 respondents were rated as "Very Satisfactory." Lastly, the third in rank is the total of 118 (14%) out of 873 respondents who had final grades rated as "Outstanding." It is also noticed that 14 respondents did not achieve the learning competencies. Based on the feedback of the Math teachers in the selected schools, these respondents were still in the process of

remediation through modular set-up. Based on a random sample of 873 respondents, the overall final grade of 83.82 indicates that Grade 11 respondents had a satisfactory level of academic performance in General Mathematics.

Table 7. Academic performance of the respondents in general mathematics

INDICATORS	f	%	RANK
Outstanding (90 – 100)	118	14	3
Very Satisfactory (85 – 89)	252	29	2
Satisfactory (80 – 84)	302	35	1
Fairly Satisfactory (75 – 79)	187	21	4
Did Not Meet Expectations (74 and Below)	14	1	5
Total	**873**	**100**	
Overall Average Final Grade	**83.32**		

This result of having a large proportion of students in satisfactory Mathematics academic performance was also evident in the study of Capinding (2021) which indicated that 64 (30.33%) out of 211 Grade 11 students had Mathematics grades ranging from 85 to 89. However, the related study by Herrera (2019) revealed that the majority of the 156 respondents during the pre-pandemic school year had final grades in General Mathematics between 75 to 79.

3.4 Test of Relationship between Online Learning Constructs and Mathematics Academic Performance of the Respondents

The Spearman rank correlation coefficient was utilized due to the assessment of online learning constructs being determined through a Likert scale instrument. Additionally, the academic performance was assumed to be non-normally distributed, as indicated by p-values less than 0.05 obtained from the Shapiro-Wilk Test.

Table 8. The extent of the relationship between online learning constructs and mathematics academic performance

VARIABLES	ρ	P-VALUE	INTERPRETATION	DECISION
Motivation and Academic Performance	0.328	< 0.001	Significant	Reject Ho
Access and Use of Technology and Academic Performance	0.356	< 0.001	Significant	Reject Ho
Perception of Online Learning and Academic Performance	0.351	< 0.001	Significant	Reject Ho
Self-directed Learning and Academic Performance	0.305	< 0.001	Significant	Reject Ho
Online Teaching Approach and Academic Performance	0.334	< 0.001	Significant	Reject Ho

Table 8 presents the extent of the relationship between the online learning domains and the academic performance in General Mathematics of the respondents. The matrix shows that all variables were positively and significantly correlated with the mathematics academic performance of the respondents. However, it was noticed that each correlation coefficient is verbally interpreted as a low positive association which urges further recommendations. Motivation in online learning and Mathematics academic performance were significantly and positively correlated based on the computed correlation coefficient of 0.328 and p-value of <0.001. However, the low positive association of 0.328 between the variables under study encourages teachers to create action plans. It indicates a relatively weak association between these variables. This means that while there is a positive relationship, other factors may also be influencing Mathematics academic performance. Math educators need to consider these additional factors when seeking to improve student performance in Mathematics, even if motivation in online learning is high. Access and use of technology and mathematics academic performance were significantly correlated with a positive correlation of 0.356 and a p-value of <0.001. Similarly, having an outcome of a low correlation coefficient even if it is significant calls for the creation of online learning enhancement programs. Perception of online learning and Mathematics academic performance were significantly associated based positive correlation coefficient of 0.351 and a p-value of <0.001. Since the correlation coefficient is low, this can be attributed to the various challenges, and problems that students experienced. Self-directed learning and Mathematics academic performance were significantly and positively associated based on the computed correlation coefficient of 0.305 and p-value of <0.001. Online teaching approach and Mathematics academic performance were significantly correlated based on the p-value of <0.001 and positive correlation coefficient of 0.334.

The results on motivation confirm the study of Capinding (2021) which unveiled that student motivation is a determinant of Mathematics academic success. In terms of access and use of technology, this was supported by

Maheshwari (2021) who found out that ICT infrastructure and access to the internet were associated with student's online learning intentions. The result obtained in the case of perception of online learning is related to the studies of Purwadi et al. (2021), Baczek et al. (2021), and Pinar (2021) which resulted in different findings of having positive perceptions and negative perceptions in online learning.

In terms of self-directed learning, this affirms the study of Pepito and Acledan (2022) which found that online learning success and self-directed learning were significantly correlated. Lastly, the findings on the online teaching approach were parallel to the findings of Bhowmik and Bhattacharya (2021) who investigated instructional factors, student factors, and teacher factors as variables of online learning. Before the pandemic, Herrera (2019) had empirical evidence which did not support the current findings. According to Herrera (2019), teacher-related variables such as teaching strategy, mastery of the content, use of instructional materials, and teaching attitude were not significantly correlated with mathematics academic performance.

3.5 Relationship Between Content Proficiencies and Mathematics Academic Performance

Table 9. The extent of relationship between content proficiencies and mathematics academic performance

VARIABLES	ρ	P-VALUE	INTERPRETATION	DECISION
Content Proficiencies and Academic Performance	0.352	< 0.001	Significant	Reject Ho

Table 9 reveals the association between the online learning dimensions and the mathematics academic performance of the respondents. The assessment of respondents' content proficiencies in General Mathematics and academic performance had a significant association based on the coefficient of 0.352 and p-value <0.001. It implies that as the mathematical content knowledge and skills of students enhance, their academic performance improves.

The findings on content knowledge and skills contradict the study of Cordova and Tan (2018) conducted at Valencia, Bukidnon which found that the mathematics proficiency of students was not correlated with academic performance. On the other hand, the current result confirms the study of Callaman and Itaas (2020) which revealed that mathematical skills and academic performance were significantly correlated.

3.6 Testing of the Assumptions for a Multiple Linear Regression and Utilization of the Findings

Before conducting multiple linear regression, a series of diagnostic tests were done to determine whether there are potential violations of the assumptions such as multicollinearity, heteroscedasticity, and normality of residuals, ensuring the reliability and validity of the regression model. It helps assess the robustness of the model, enhances the accuracy of predictions, and informs adjustments or transformations to improve the overall quality of the regression analysis (Amora, 2023).

Normality of the Residuals and Presence of Multivariate Outliers

Table 10 presents the residual statistics consisting of the standard residuals, Mahalanobis distance results, and Cook's distance values. The standard residuals in the interval of $-2.953\ to\ 2.156$ is a good indication since the values lie in the standard residual interval of $-3\ to\ 3$. The result of the Cook's Distance at 0.000 which is not greater than 1 indicates that the data set has no multivariate outliers. Mahalanobis values ranging from 0.636 to 5.729 underwent examination and testing through the Chi-square distribution, yielding non-significant results. Consequently, no significant multivariate outliers were observed in the dataset.

Table 10. Normality of the residuals and presence of multivariate outliers

	MINIMUM	MAXIMUM	MEAN	SD	N
Residual	-12.96	17.53	0.000	4.37	873
Standard Residual	-2.953	2.156	0.000	0.997	873
Mahalanobis Distance	0.636	5.729	5.993	3.762	873
Cook's Distance	0.000	0.068	0.001	0.003	873

Figure 1 depicts the scatter plot of the residuals (error terms). As noticed from the graph, data points being plotted did not fall beyond -3.0 and 3.0, which indicates a relatively well-behaved and homoscedastic pattern of residuals. This suggests that the variability of the errors remains fairly constant across the range of predictor values. The limited spread of residuals within the -3.0 to 3.0 range indicates that the model's predictions are

generally consistent and that there are no significant outliers or systematic patterns of deviation from the expected values. This homoscedasticity is a positive characteristic in regression analysis, contributing to the reliability of the model's predictions and the validity of statistical inferences drawn from the data.

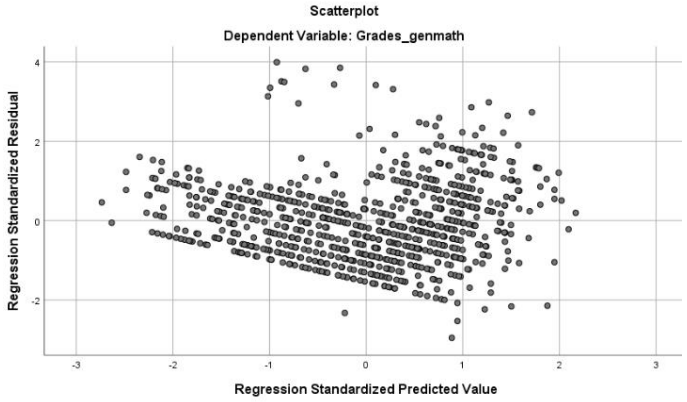

Figure 1. Scatter Plot of the Residuals

Figure 2 presents the normal p-p plot of the residuals of the regression line. One of the requirements of performing multiple linear regression is the normality of the error terms or residuals (Yambot, 2020). As noticed from the graph, the points lie closer to the straight line which is an indication that the error terms were assumed to exhibit an approximate normal distribution.

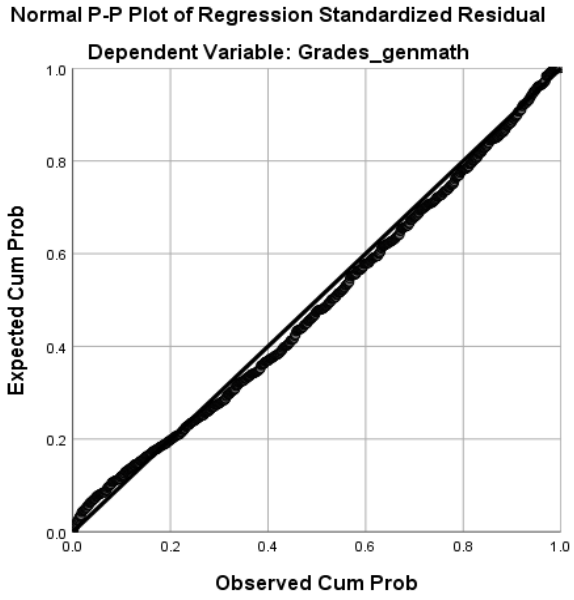

Figure 2. Normal P-P Plot of the Residuals

Regression Analysis of Variance (ANOVA)

The findings from another assumption test, as illustrated in Table 11, ascertained whether the slope of the regression line is equal to zero. Given the test was significant at $p < 0.001$, it can be inferred that the slope of the regression line is not equal to zero, indicating that the line is not horizontal.

Table 11. Regression analysis of variance

	SUM OF SQUARES	DF	MEAN SQUARE	F	P-VALUE
Regression	5295.46	4	1323.87	68.64	< 0.001
Residual	16740.87	868	19.29		
Total	**22036.33**	**872**			

Coefficients and Collinearity Statistics

Table 12. Coefficients and collinearity statistics

VARIABLES	β	STD. ERROR	STANDARDIZED COEFFICIENTS	t	P-VALUE	TOLERANCE	VIF
Constant	68.366	0.954		71.628	< 0.001		
Content Proficiencies	0.186	0.021	0.275	9.074	< 0.001	0.937	1.068
Motivation	1.045	0.293	0.119	3.572	< 0.001	0.742	1.348
Access and Use of Technology	1.195	0.232	0.178	5.156	< 0.001	0.333	2.999
Perception of Online Learning	0.036	0.346	0.005	0.103	0.918	0.314	3.188
Self-Directed Learning	0.510	0.295	0.060	1.726	0.085	0.730	1.370
Online Teaching Approach	1.001	0.232	0.151	4.315	< 0.001	0.675	1.481

Table 12 reveals the coefficients of the regression equation with their corresponding p-values and the variance inflation factor per variable. The coefficients of the regression model served as the average change in the mathematics academic performance for every unit of change in each independent variable. As observed from the table, each variance inflation factor (VIF) is less than 4 which indicates that there was no evidence of serious multicollinearity among the predictors (Yambot, 2020). This shows that the predictors were not highly correlated to each other. Based on the results, the test is significant as evidenced by each computed p-value of less than 0.05 for the following independent variables: content proficiencies in mathematics, motivation, access and use of technology, and online teaching approach.

Content proficiencies in General Mathematics were revealed as a significant positive linear predictor of mathematics academic performance as shown in the p-value less than 0.001 and positive coefficient of 0.186. Motivation in online learning was found to be a significant positive linear predictor of Mathematics academic performance based on the p-value of <0.001 and a positive coefficient of 1.045. This shows that as the students become motivated to study mathematics online, it results in better academic performance. Access and use of technology were revealed as significant positive linear predictors of Mathematics performance as indicated in the p-value of < 0.001 and a positive coefficient of 1.195. This implies that a more extensive use of technology is associated with improved mathematics performance. Similarly, the online teaching approach demonstrates its significance as a positive linear predictor, supported by a highly significant p-value of <0.001 and a positive coefficient of 1.001. This underscores the effectiveness of the online teaching methodology in contributing to favorable mathematics academic outcomes. On the other hand, the perception of online learning and self-directed learning were found to be not significant linear predictors of Mathematics academic performance of the respondents based on the p-values of 0.918 and 0.085. While these variables are significantly correlated with mathematics academic performance, they have limited ability to predict the academic performance of the respondents in the subject due to the computed weak correlation coefficients. This suggests that these factors may not play a substantial role in influencing mathematics performance among the respondents.

The results on content proficiencies and academic performance of the students confirmed the findings in the study of Callaman and Itaas (2020) which unveiled that mathematical skill is a predictor of students' academic performance. However, the results were different from the study of Cordova and Tan (2019) before the pandemic as they revealed no relationship between mathematical proficiency and academic performance. The findings on motivation and Mathematics academic performance were supported by the empirical results made by Capinding (2021) which pointed out that students' Mathematics motivation is a determinant of academic performance. As compared to the study of Mamolo (2022), student's Mathematics motivation has decreased significantly in synchronous classes which differs from the result of having a positive trend in motivation and final grades. Furthermore, the findings regarding access to and use of technology and Mathematics academic performance are consistent with Garcia et al. (2020), who found that the availability of ICT resources in schools positively influences students' mathematics academic performance. In contrast, the results of the model contradict the study of Aumentado (2021), which found no correlation between technological domains and

Mathematics academic performance. The lack of dependency of academic performance on perceptions of online learning and online teaching approach differs from Gopal et al. (2021), which indicated that the quality of online instruction influences student satisfaction in online learning, leading to improved class performance.

Model Summary

Table 13. Model summary

R	R^2	Adjusted R^2	Standard Error of the Estimate	R Square Change	F-Change	df 1	df 2	Sig. F-Change	Durbin-Watson
0.493	0.243	0.238	4.39	0.243	68.64	4	868	0.000	1.268

Table 13 shows the substantiality of the model based on the coefficient of determination R^2 and the result of the Durbin-Watson test. While Table 12 presents noteworthy findings, the overall robustness of the regression model is somewhat limited, given the coefficient of determination of 24.3%. This suggests that only a quarter of the variability in mathematics academic performance is accounted for by the independent variables in the model. The proportion of 76% of unexplained variances may be attributed to factors not considered in the analysis, underscoring the need for exploration of additional predictors.

Additionally, the Durbin-Watson test statistic of 1.268 assures that the error terms within the model exhibit independence. The Durbin-Watson statistic should be within the range of 1.5 to 2.5 (Azami et al., 2020). This suggests that there is no systematic pattern of correlation among the residuals, reinforcing the reliability of the model's assumptions and highlighting its ability to provide unbiased estimates. However, the relatively low coefficient of determination emphasizes the importance of further research to uncover and incorporate additional variables that might contribute to a more in-depth and profound understanding of the dynamics influencing mathematics academic performance.

The estimated multiple linear regression model is given by: $\hat{Y} = \beta_1 x_1 + \beta_2 x_2 + \beta x_3 + \beta x_4 + \beta_0 + \varepsilon$ is shown below:

$$\boldsymbol{\hat{Y} = 0.186x_1 + 1.045x_2 + 1.195x_3 + 1.001x_4 + 68.366}$$

Where:

$\hat{Y}$ = Predicted value of Mathematics academic performance
x_1 = Observed value of Content − Based Competencies,
x_2 = Observed value of Motivation
x_3 = Observed value of Access and Use of Technology
x_4 = Observed value of Online Teaching Approach
ε = Error Terms or Residuals

4.0 Conclusion

Despite the challenges posed by the pandemic, the student respondents displayed impressive motivation and enthusiasm for online mathematics education, highlighting the potential of online platforms in facilitating effective learning even in difficult circumstances. Moreover, their proficient technology usage demonstrated their adaptability and competence in utilizing digital tools for learning, ensuring a seamless integration of technology in education. The students' positive attitudes towards online learning further emphasized their favorable perception of this mode of education, fostering increased engagement and improved learning outcomes. Additionally, their self-directed learning traits showcased their ability to take ownership of their learning, a valuable skill in remote learning environments.

It can be inferred from the findings that the respondents demonstrated an outstanding level of performance in the domain of Functions and their Graphs, likely due to sufficient instructional time dedicated to these lessons during the first quarter. However, there is room for improvement in the competencies associated with Mathematics of Investment and Math Logic. These results emphasize the importance of targeted interventions and focused instruction to strengthen these specific areas of General Mathematics, typically covered in the second quarter of the first semester. By addressing these competencies, educators can effectively support students in achieving enhanced performance and a comprehensive understanding of the subject.

The satisfactory academic performance of Grade 11 students in General Mathematics, with a notable proportion achieving grades between 80 and 84, embarks the effectiveness of teaching strategies resulting in students' developing phase of learning. The presence of students who attained a very satisfactory level further validates the success of the teaching methodologies and instructional materials used. However, it remains important to provide ongoing support and vigilance for students who may require additional assistance in their continuous development and success. Additionally, it is necessary to acknowledge that a minority of respondents did not meet the required learning competencies, prompting the implementation of remedial interventions through a modular approach.

The positive significant association of the online learning dimensions and mathematics academic performance infer that when students demonstrate high levels of motivation, have adequate access to technology, hold positive perceptions of online learning, exhibit self-directed learning behaviors, and experience effective online teaching, they are more likely to perform well in mathematics. The observed relationship among these variables was unlikely to have occurred by chance. However, the low correlation coefficients indicate that additional challenges and issues experienced by students may have influenced the outcomes. Thus, there is a call for the development of online learning enhancement programs and the implementation of effective strategies to address these challenges and improve overall academic performance in General Mathematics.

A multiple linear regression model of academic performance was derived based on the significant results of the stepwise method. The model implies that several independent variables, including content-based competencies, motivation, access and use of technology, and online teaching approach, were found to be significant linear predictors of mathematics academic performance indicating that higher levels of these variables can lead to better academic outcomes. This formulated a linear model that can explain academic performance will serve as the basis for creating academic policies, guidelines, and development of the curriculum in mathematics education in a remote learning context.

In light of the study's findings and conclusions, the researcher presents the following recommendations:

Students are encouraged to enhance their technological skills by actively engaging with educational software, watching tutorials on platforms like YouTube, and enrolling in short computer courses. Improving self-directed learning skills is also crucial, achieved through better study habits, understanding learning goals, and creating study guides. Special Mathematics classes can further enhance competencies for senior high school, preparing students for the National Achievement Test and their chosen tertiary education track.

For senior high school mathematics teachers, intensified teaching efforts through enrichment classes and back-to-basics lessons are advised, focusing on areas like Mathematics of Investment and Logic. Action research on variables of online learning and open high school programs is also recommended. Developing a Mathematics Learning Enhancement Program (MLEP) for Grade 11 students can cater to both advanced and developing learners, saving time in covering competencies. Proposing teaching innovations and online learning intervention programs can enhance student learning effectiveness and positive online experiences.

Parents should create a home monitoring system to support their children's online learning and study habits. They should also participate in training to understand student learning psychology and their role in boosting academic performance. School leaders should develop online programs that enhance self-directed learning skills, while initiatives like the Mathematics Learning Enhancement Program can benefit students in both STEM and non-STEM schools. The Department of Education should evaluate the effectiveness of the Open High School program, which offers distance learning through online and modular approaches, and simplifies essential learning competencies in General Mathematics. Future research should explore factors affecting mathematics academic performance in online learning, considering the unexplained variances in current regression models.

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All authors declare that they have no conflicts of interest

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